UNIVERSITY OF LONDON
INSTITUTE OF ARCHAEOLOGY

GEOCHRONOLOGICAL TABLE No. 3

THE CHRONOLOGY OF THE IRISH STONE AGE

BY

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EDITORIAL NOTE

The *Geochronological Tables* are intended to provide chronological information in tabular form, with a text as concentrated as possible and chiefly supplying the sources from which the tables in question are derived. As a rule, the series is not supposed to include original papers, but to supply the results of recent chronological work in an easily surveyable form, especially for the purpose of instruction. It is not restricted to any particular period.

The following numbers have appeared:

1. *An Attempted Correlation of Quaternary Geology, Palaeontology and Prehistory in Europe and China.* By WEN-CHUNG PEI (Peking). 1939.
2. *The Age of Neanderthal Man, with Notes on the Cotte de St. Brelade, Jersey, C. I.* By F. E. ZEUNER (London). 1940.
3. *The Chronology of the Irish Stone Age.* By HALLAM L. MOVIUS, Jr. (Harvard University). 1940.

Numbers in preparation will deal with the Postglacial chronology (Neolithic and Bronze Age), the human finds and industries of Java, the Palaeolithic fauna of temperate Europe, the early civilizations of the Near East, dating of geological periods with the aid of radioactivity, etc.

F. E. ZEUNER

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THE CHRONOLOGY OF THE IRISH STONE AGE

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1. INTRODUCTION

AS yet no archaeological material clearly demonstrating that Ireland was occupied during Palaeolithic times has been found. Although it is possible that future research will establish the fact that Old Stone Age hunters settled in this area during the Glacial Period, present data indicate that the earliest material yet discovered is referable to a Mesolithic culture which is Post-Glacial in age. Since this culture has been recognized as an independent and indigenous development (Movius, 1940), it is necessary to date it by as many different indices as possible—geology, palaeontology, climatology and palaeobotany. Early workers in Ireland made the mistake of attempting to date the various deposits by comparing the contained artifacts with similar material from Northern and Western Europe. This typological method is, however, only practical for checking results in regions where the archaeological sequence rests on a firm foundation of stratigraphy, and it is illogical to expect such a system to apply in a region where, because of geographical position or other factors, there is a possibility of encountering a new and distinctive culture. By treating special types of implements as isolated abstractions, the typologist completely obscures not only the picture of a culture as a functioning unit, but he also loses sight of the time factor as revealed by the stratigraphic position of the material under consideration. Furthermore, an interpretation of the material can only be extended along very superficial lines unless the background of environmental factors, in so far as a reconstruction of them can be made, is clearly understood. This paper is an attempt to summarize the evidence which makes it possible to date the Irish deposits containing a new Early Post-Glacial culture—the Larnian—in terms of the well-established Scandinavian sequence. In order to provide a firm basis of correlation between Northern Europe and Ireland, it is obvious that the evidence from Britain must be considered. It is also necessary to discuss the recession of the last ice-sheets in the British Isles and the geographic factors contingent upon their withdrawal. In this way it is possible to arrive at a satisfactory conclusion regarding the earliest period when North-East Ireland became available for settlement, and also to date the implementiferous deposits. A summary of the results is presented in the form of a correlation table (Fig. 2).

2. GLACIAL ERAS

During the last ten years, work in the periglacial region of Central Europe makes it appear reasonably certain that the Weichsel Glaciation of Scandinavia is the equivalent of Würm II in the Alps, and that the Pomeranian Stage, which indicates a re-advance following the first retreat period (Daniglacial), may be equated with

Würm III (Zeuner, 1935). The Alpine sequence is not altogether clear beyond this point. In Scandinavia, however, two more periods of retreat—the Gotiglacial and the Finiglacial—have been recognized. These were separated by a prolonged halt when the great Fennoscandian Moraines were formed. The end of the Finiglacial Period is fixed by the bipartition of the ice at Ragunda in Jämtland, an event which occurred in 6800 B.C. (De Geer, 1910 and 1927). Following the De Geer system, which has been explained by Clark (1936, pp. 4–7), the earliest authentic date is ± 14,800 B.C. (De Geer, 1928), since the date of ± 18,000 B.C. for the beginning of the Pomeranian Stage is based on computation only and not on actual varve counts. The Fennoscandian halt occurred in ± 8300 B.C. and in ± 7800 B.C. the third period of retreat—the Finiglacial—began. This sequence provides the basis for dating comparable events in Britain and Ireland.

As shown in Fig. 1, during the last glacial maximum in Britain, the ice-sheets advanced to the York Line (Charlesworth, 1929 ; Wright, 1937, Fig. 39) and deposited the Upper Purple boulder clay of Western Yorkshire (Raistrick, 1933), as well as the Hunstanton-Hessle boulder clays of the east coast (Boswell, 1931, 1932, 1935 and 1936; MacClintock, 1933; Sandford, 1932, 1933, 1933(*a*) and 1935; Solomon, 1932; Zeuner, 1937 and 1938). It is generally recognized that this episode is the equivalent of the Weichsel Glaciation (Würm II) of Northern Europe. A small section of Southern Wales was ice-free at this time (Charlesworth, 1929; Griffiths, 1939; George, 1933; Pringle and George, 1937), and over three-quarters of Ireland was covered with local Ivernian Ice, confluent with Irish Sea Ice on the east coast, which advanced to the Southern Irish End-Moraine (Charlesworth, 1928; Farrington, 1939). It appears likely that the Upper Flood Plain Terrace, Stage 2, of the Lower Thames Valley (King and Oakley, 1936) was formed at this period. The Scottish equivalent of this "New Drift Glaciation" of England and Ireland is known as the Strathmore Glaciation (compare: Bremner, 1928, 1934, 1934(*a*) and 1934(*c*)). As indicated on the map (Fig. 1), the Strathmore Ice flowed northward along the east coast of Scotland, a direct result of the pressure exerted by the Scandinavian Ice which covered the area of the present North Sea. In the region south of the Scottish Highlands a typical Late Pleistocene fauna has been documented from interstadial deposits underlying New Drift boulder clays (Gregory and Currie, 1928; Ritchie, 1929). This assemblage includes Mammoth, Reindeer, Woolly Rhinoceros, Wild Ox, Irish Elk (?), Red Deer and Wild Horse. Of this list the Mammoth at least reached Ireland (Charlesworth, 1928 and 1930). Although there were many centres of ice-dispersal in Britain and Ireland which contributed to the New Drift Ice-Sheet, the most important one was situated in the Highlands of Scotland.

Following the First Retreat Period the major part of England was ice-free, as indicated in Fig. 1. But in the north-east a re-advance of the ice from the Southern Uplands of Scotland, known as the Scottish Re-advance, occurred, and the Cumberland Plain was once more glaciated (Trotter and Hollingworth, 1932 and 1932(*a*); Trotter, 1929). This ice advanced on to the northern plain of the Isle of Man (Smith,

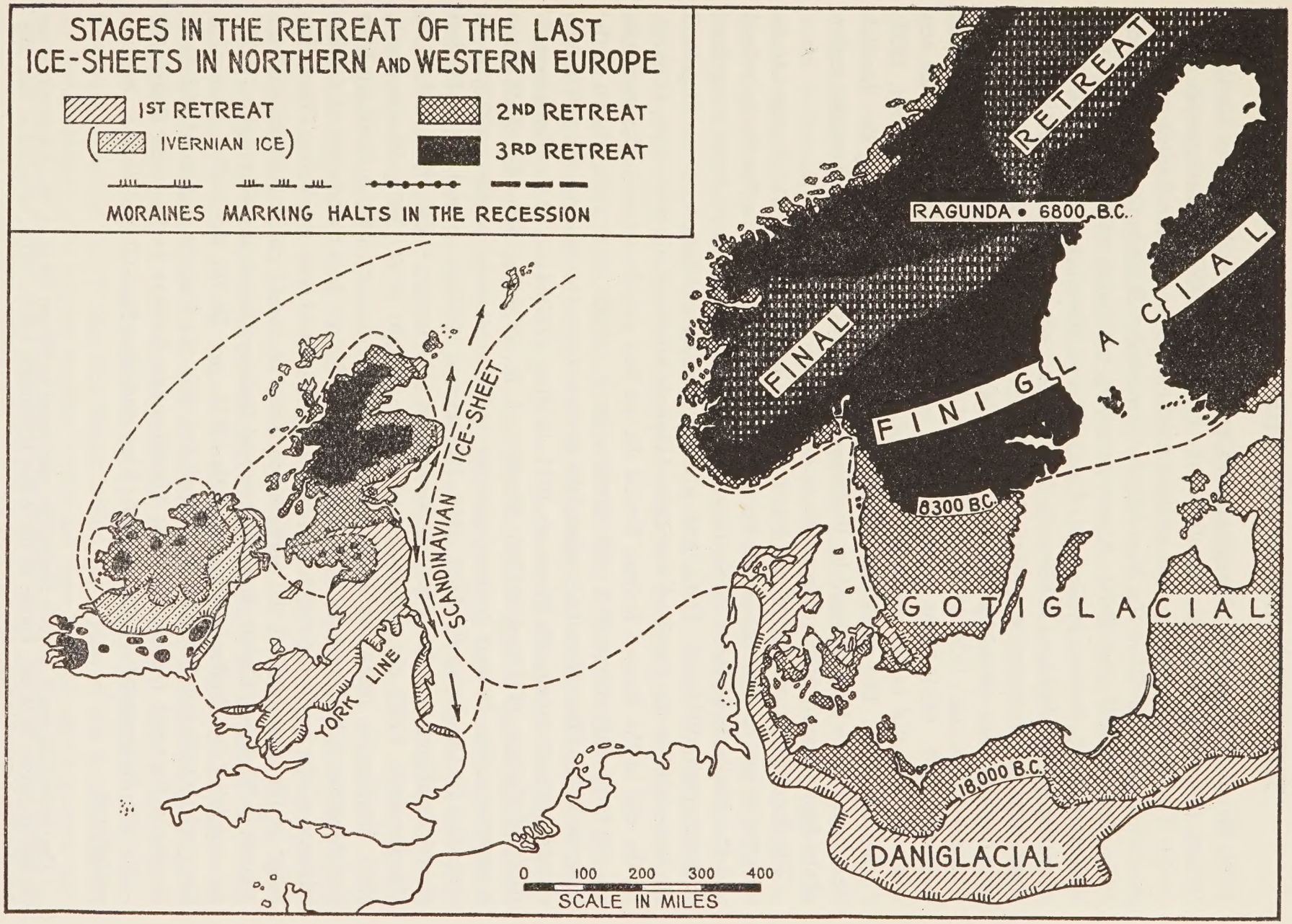
STAGES IN THE RETREAT OF THE LAST ICE-SHEETS IN NORTHERN AND WESTERN EUROPE
1ST RETREAT
IVERNIAN ICE
2ND RETREAT
3RD RETREAT
MORAINES MARKING HALTS IN THE RECESSION
RETREAT
RAGUNDA • 6800 B.C.
FINAL
FINIGLACIAL
8300 B.C.
GOTIGLACIAL
SCANDINAVIAN ICE-SHEET
YORK LINE
18,000 B.C.
DANIGLACIAL
0 100 200 300 400
SCALE IN MILES

Fig. 1

1930; Slater, 1931) as well as the coasts of Counties Antrim and Down in North-East Ireland (Dwerryhouse, 1923; Charlesworth, 1926(*a*) and 1939; Charlesworth *et al.*, 1935). The Scottish Re-advance without question represents the British and Irish equivalent of Würm III in the Alps and the Pomeranian Stage in the Baltic (Boswell, 1936; Zeuner, 1937 and 1938). A corresponding oscillation of the Ivernian Sheet is documented in Ireland by the great Central Plains Moraines (Charlesworth, 1928), when the ice was deployed in three confluent lobes issuing from the mountains of the north-west. In the region west of the Bann Valley the position of the ice-front at this time has also been traced by Charlesworth (1924). In Eastern Scotland the Highland Glaciation (Bremner, 1934, 1934(*a*), 1934(*c*) and 1936), of which the Perth Re-advance (Simpson, J. B., 1933) forms a part, may be correlated with this stage. The ice was still very powerful in the north and west of Scotland (Read, 1935; Richey, 1935; Phemister, 1936). The moraines formed by the Highland Ice during the Scottish Re-advance have been mapped by Professor Charlesworth (1926(*a*)) from the region of the Lammermuir Hills to Stranraer in Southern Scotland (Fig. 1).

The Second Retreat Period was interrupted by several oscillations; it seems to be the counterpart of the Gotiglacial Period in Northern Europe. In Northern Ireland and the Southern Uplands of Scotland several minor stages have been recognized (Charlesworth, 1924 and 1926), and a corresponding oscillation of the Highland Ice is revealed by the Pentland–Carstairs–Maybole Moraines (Charlesworth, 1926(*a*)). By the end of the Second Retreat Period the ice had withdrawn from the lowlands, but the temporary return of a cold climate caused a slight re-advance, known as the Stage of Valley Glaciation. In Scotland the limits of the ice at this time are well known except in the extreme north (Bremner, 1921, 1934(*a*), 1934(*b*) and 1936; Charlesworth, 1926; McCallien, 1937 and 1937(*a*); Simpson, J. B., 1933, pp. 641–645). This phase is represented in Ireland by local glaciers in the mountains of the north-west as described by Charlesworth (1924, 1928, 1928(a) and 1929(a)), as well as by the last glacial maximum in the Wicklow Mountains (Farrington, 1934, 1938 and 1939; Charlesworth, 1937), the mountains of Kerry (Wright *et al.*, 1927; Charlesworth, 1928; Farrington, 1936) and other sections of Ireland south of the Southern Irish End-Moraine (Charlesworth, 1928; Farrington, 1938(*a*)). This correlation of the last advance of the ice in the mountains of Southern Ireland with the Valley Glaciation Stage in the mountains of the north is confirmed by recent palaeobotanical investigations in Wicklow, Cavan, Roscommon and Galway (Jessen and Farrington, 1938). As suggested by Professor Charlesworth (1931, pp. 76–78) the Valley Glaciation Stage of Britain and Ireland may be equated with the Fennoscandian Moraines of Northern Europe.[1] During the next Scandinavian Retreat Period—the Finiglacial —the ice disappeared in the British Isles and the Post-Glacial forests became established.

[1] On the basis of recent work in Shropshire, mentioned by Wright (1937, p. 94), it is possible that the last glaciation of Wales, known as the Welsh Re-advance (Wills, 1937), occurred at this time. But this has not as yet been demonstrated.

That the retreat stages of the last ice-sheets in Britain and Ireland should reflect in so striking a manner the established Scandinavian succession is not surprising. It is generally maintained that glaciation in the former areas was mainly in response to the general cooling effect caused by the neighbouring Fennoscandian Ice (Leverett, 1929, p. 752). Thus it follows that, as the ice receded in Northern Europe, any phenomena connected with its retreat would also be documented in Britain and Ireland. The correlation proposed above is not only confirmed by synchronous changes in the mutual level of land and sea in the regions under consideration, but also by a corresponding climatic development which in turn directly affected the flora and fauna in each case.

3. Land Movement

In addition to the synchronisms between the stages in the retreat of the last ice-sheets in Britain and Ireland as compared with those of the Baltic, the changes in the mutual level of land and sea during Late-Glacial and Early Post-Glacial times in these regions follow an identical pattern. The relative importance of rise and fall of land and alterations in the volume of the ocean in producing apparent changes in level at various periods is not considered here. Thus the terms submergence and emergence are used throughout without any attempt to distinguish between eustatic and isostatic factors.

A. Late-Glacial Period.—At the time of the New Drift—Weichsel Glaciations—the land was depressed under the weight of the ice-load, and as the recession continued the sea transgressed the ice-free portions of the coast. In Northern Europe this led to the formation of extensive marine deposits and raised beaches containing an arctic fauna (Daly, 1934), which are at varying heights depending upon the amount of recoil that has taken place since this period. In Northern Britain and Ireland a precisely similar series of phenomena are found. Not only are there extensive raised beaches (compare: Bremner, 1920; Bailey *et al.*, 1925 and 1930; Dinham, 1927; Martin, 1930; Phemister, 1936; Richardson, 1940; Simpson, J. B., 1933) and marine clays (compare: Brown, 1867; Howden, 1868; Jamieson, 1865), but they likewise contain an arctic fauna (Macgregor and Macgregor, 1936). Moreover, as Dinham (1927), McCallien (1937), J. B. Simpson (1933) and Wright (1911, 1928 and 1937, pp. 368–376, Fig. 128, have shown, they are associated in Scotland with the Highland Glaciation (Scottish Re-advance), the Second Retreat Period and the Valley Glaciation; with this latter event most of the Late-Glacial raised beaches in Western Scotland may be correlated. This indicates that the Late-Glacial Sea in Northern Britain and Ireland occupies a position in the sequence almost exactly corresponding to that of the Ice-Dammed Lake and the Yoldia Sea Stages within the region of the present Baltic. As in Scandinavia, the highest beaches, which are over 100 feet above present sea-level, are situated around the main centre of glaciation (in this case the Highlands of Scotland). Here marine terraces are found at successively lower levels—75, 60, 65

feet, etc.—which document the recovery of the land as uplift began in consequence of its liberation from the ice-load. By careful mapping and connecting the points of equal elevation, the isobases, or contours, of the depression may be established.

B. Early Post-Glacial Period.—After the retreat of the ice the evidence from Britain and Ireland reveals that the movements affecting the mutual relation of land and sea also follow the well-known Baltic sequence. During Boreal times there was a period of emergence which resulted in a greater extension of land than at present. This excluded the sea, and the Ancylus Lake occupied the region. The Atlantic Period witnessed a second lowering of the land with respect to the ocean, and with this submergence the Baltic basin was filled with a body of salt-water, known as the Litorina Sea. Subsequent emergence led to the establishment of present conditions.

As proved by peats on the floor of the North Sea (Erdtman, 1924; Reid, 1913) formed during the Early Post-Glacial emergence, there was a complete land-bridge between Britain and the Continent at this time (Clark, 1936 and 1936(*a*); Godwin, 1933 and 1934; Jessen, 1935). Whereas the factors pertaining to the movements are extremely complex (compare: Godwin, 1940), palaeobotany demonstrates that this land connection was terminated at the beginning of the Litorina Phase in the Baltic. Therefore the marine transgressions in Britain and Northern Europe are synchronous, a fact which has been confirmed by a study of freshwater animals whose distribution is controlled by climatic factors (Ullyott, 1936).

Submerged peats dating from the period of emergence are extensively developed in England (Austen, 1851; Boswell, 1937; Reade, 1871; Reid, 1913; Shore and Elwes, 1889; Strahan, 1896; Wood and Rome, 1868), as well as in Scotland (Erdtman, 1928; Howden, 1868; Jamieson, 1865; Wright, 1937; pp. 376–381 and Ireland (Charlesworth and Erdtman, 1935; Hallissy, 1914; Jessen, 1940; Praeger, 1888 and 1904). Furthermore they often overlie marine deposits of the Late-Glacial Sea. As in the case of the British-Continental land-bridge, this period was brought to an end by a phase of relative submergence when the sea transgressed the land and the coast-line was from 25 to 40 feet higher than at present with respect to sea-level. As a result of the emergence, which began in the Late Atlantic Period as in the Baltic, the Early Post-Glacial marine deposits were raised to their present position—the region of greatest uplift again being adjacent to the Scottish Highlands (compare: Dinham, 1927; McCallien, 1937; Simpson, J. B., 1933, p. 640). During the maximum of the submergence, Scotland north of the Midland Valley was only connected to the rest of Britain by a narrow isthmus (Erdtman, 1928, p. 181; Jamieson, 1865, Fig. 1). The raised beaches formed at this time (Hull, 1872; Farrington, 1933; Martin, 1930; Praeger, 1896; Wright, 1925, 1928, 1934) consist of: (*a*) gravels and sands laid down under water and subsequently raised to their present position—these deposits are not true beaches—and (*b*) storm beaches formed primarily by wave-action under conditions of a rising shoreline. In Northern Ireland there are likewise finer sediments, known as estuarine clays (Praeger, 1892), which were accumulated along certain portions of the coast where marine currents and wave-action were slight. These clays are important since

they contain (*a*) pollen which fixes the period of deposition as Atlantic in terms of the Blytt-Sernander system, and (*b*) molluscs which reveal that the Post-Glacial climatic optimum was attained during this period. In fact, as Dr. Praeger has shown (1896, pp. 47–48), "southern" forms prevailed in the Litorina Sea, whereas to-day these extreme warmth-loving animals are no longer extant in Northern British and Irish waters. The coarse clays of Scotland also seem to belong to this period (Erdtman, 1928). During the submergence erosion was active and numerous caves and rock-cut terraces were formed. After the body of water occupying the Baltic basin at this stage, it is proposed to call the extensive gravel and sand deposits formed by the sea at the same time in Northern Britain and Ireland Litorina Raised Beaches. It should be stressed that the allied sciences considered here—geology, palaeontology and palaeobotany—all demonstrate that the sediments under consideration are of the same age as corresponding ones in Northern Europe.

4. The Partial Land-Bridge between Britain and Ireland

As Professor Charlesworth has pointed out (1930, pp. 383–388), the following observations make it seem reasonably certain that during the period of the Early Post-Glacial emergence (Boreal), Ireland and Britain were connected by at least a partially complete land connection—(*a*) the discontinuous distribution of the present-day Irish flora and fauna with that of Britain (the two regions had developed fairly uniformly until the end of the Boreal Period), (*b*) the existence of submerged peats along the littorals of both countries, and (*c*) the occurrence of drowned valleys off the west coast of Britain. The latter have also been noted in the south of England (Reid, 1913; Jones, O. T., 1934, p. 308), but those in the valleys of the Severn (Wills, 1938, p. 216) and the Tawe (Jones, O. T., 1934, p. 306) have a more direct bearing on the present problem. The deepest recorded instances are off the Cheshire and Lancashire coasts, since the Early Post-Glacial valleys of the Ribble, Mersey and Dee Rivers have been traced to between the 16 and 25 fathom lines (Gresswell, 1936). Indeed at the time of the emergence the Ribble excavated a channel $\pm$ 150 feet deep in the glacial deposits of Lancashire; this channel was subsequently filled with Post-Glacial sediments (De Rance, 1870). Submerged peats have been reported at many localities in areas bordering on the North Sea floor, although off the Formby and Wirral coasts there are peat layers demonstrating that the land stood $\pm$ 120 feet higher than at present at the time of their formation (Gresswell, 1936). On this basis the 20 fathom line is probably a safe figure to indicate the extent of the uplift (compare: Fox, 1938, p. 23). If this amount of emergence were effected there would be a partially complete land connection between Western Britain and Ireland, but it is difficult to postulate former conditions on the basis of the present contours, which are being continually altered by marine erosion and tidal scour. Nevertheless, it seems probable that crossings could have been made with comparative ease, although

en route it would have been necessary to negotiate a narrow strait or an arm of the sea—the "Irish Channel River" (Charlesworth, 1930, p. 386, and 1936; Charlesworth *et al.* 1935, p. 483). The existence of this partial land-bridge is of obvious importance with regard to the Early Post-Glacial settlement of Ireland. It also explains the fact that the Early Mesolithic development in North-East Ireland and South-West Scotland is very similar, whereas after the Litorina transgression the Late Mesolithic of the two areas diverges to a marked degree (Movius, 1940, p. 76).

5. Climatic Phases in Northern Europe

That section of the correlation table (Fig. 2) showing the climatic phases from the Boreal Period onwards calls for no special comment except with regard to the early periods. In Denmark recent research has led to the recognition of a series of zones into which the bog sequences are divisible, and these have been synchronized with the established climatic periods (Jessen, 1935(*a*) and 1938(*a*)). This evidence is incorporated into the following summary:

A. Late-Glacial Period.—There are three Late-Glacial climatic periods which prove one amelioration and one deterioration of the climate contemporary with the retreat of the ice.

(1) *Early Dryas Period* (Zone I).—Tundra conditions are indicated by traces of *Dryas octopetala*, *Myriophyllum alterniflorum*, *Salix herbacea*, *S. nana* and various mosses. There was no local growth of Pine, but Pine pollen blown in from the south is commonly found. Deposits referable to this period usually show evidence of solifluction.

(2) *Allerød Period* (Zone II).—The Allerød Oscillation belongs in the Gotiglacial (2nd Retreat) Period when fluctuations occurred along the ice-front (Antevs, 1928; Gross, 1938). No evidence of solifluction is found in the Allerød deposits, and the contained pollen indicates cold temperate conditions. The presence of *Betula pubescens*, *Salix* sp., and wood of *Pinus sylvestris* affords conclusive proof of a marked amelioration in the climate during this phase.

(3) *Upper Dryas Period* (Zone III).—A second solifluction layer demonstrating the temporary return of arctic conditions overlies the Allerød deposits. It seems probable that this zone is synchronous with the halt of the ice at the Fennoscandian End-Moraine—± 8300 to ± 7800 B.C. (Gross, 1938). The flora associated with the Upper Dryas clays is very similar to that of Zone I, but the pollen grains are somewhat more numerous.

B. Early Post-Glacial Period.—Geologists have arbitrarily considered that the final stadium of the ice at Ragunda (± 6800 B.C.) marked the beginning of Post-Glacial time, but the Late Glacial/Early Post-Glacial boundary can now be more precisely defined in terms of climatic cycles in the Baltic. The beginning of the Pre-

Boreal Period (Zone IV) witnessed the establishment of the Post-Glacial forests, as the ice began to withdraw from the Fennoscandian Moraines. On this basis the Pre-Boreal Period corresponds with the Finiglacial Retreat Stage—±7800 B.C. to ±6800 B.C., following De Geer (1910). The forest development at this time indicates cold temperate conditions; the diagrams show a maximum for Birch (especially *B. pubescens*), the gradual ascent of Pine (*P. sylvestris*), the coming-in of Hazel (*Corylus avellana*) and the presence of Aspen. According to Professor Jessen's system the Pre-Boreal Period corresponds to Zone IV in Denmark.

For the Boreal (Zones V and VI), Early Atlantic (Zone VII) and Late Atlantic–Sub-Boreal (Zone VII) Periods the sequence seems to be clear, although as will be shown below the system of numbers established for the zones in the Baltic does not fit the Irish numerical succession. However, the two regions may be compared in terms of the Blytt-Sernander climatic periods. Recently Dr. Godwin (1940) has divided the Fenland pollen-diagrams in England into zones, which can be related both to the Blytt-Sernander periods and to Jessen's zoning of the Baltic.

6. Forest Development in Ireland

The first attempt to extend the established method of pollen-analysis, described by Godwin (1934), into Britain and Ireland was made by Erdtman (1927, 1928 and 1929) but recent intensive work (Godwin and Clifford, 1938; Godwin and Mitchell, 1938; Godwin, 1940; Hardy, 1939; Jessen and Farrington, 1938; Jessen, 1940) has revealed that the sequence is far more complex than was at first suspected. This seems to be due in the main to two factors: (*a*) the strong influence exerted on forest development by the North Atlantic oceanic climate, and (*b*) insular isolation effected by the Litorina transgression when the land connection with the Continent was severed. For the most part, however, the succession, even in Ireland, reflects in a striking manner the established Scandinavian sequence, and this is especially true of the early periods (compare: Godwin, 1934, Figs. 18 and 19). The following summary is based on the preliminary results obtained by Professor Jessen (1936, 1938 and 1940) working in co-operation with a Committee for Quaternary Research in Ireland (see *Irish Naturalists' Journal*, Vol. V, 1934, pp. 126–152), and they apply to Ireland *only*. Here the zones have not yet been clearly correlated with the British zones, but they can be synchronized fairly satisfactorily with those of the Baltic.

A. Late Glacial Period.—The same three Late-Glacial zones identified in Northern Europe have been established in Ireland (Jessen and Farrington, 1938):

(1) *Zone I.*—In Ireland arctic conditions at this stage are demonstrated by extensive solifluction deposits.

(2) *Zone II.*—According to Professor Jessen (1938, pp. 245–247) this zone, also present in the Isle of Man, corresponds to the Allerød Period of the Baltic. Cold temperate conditions existed. The Allerød muds yield remains of *Myrio-*

phyllum verticillatum, *Potamogeton*, *Betula*, *Salix*, *Juniperus*, *Empetrum*, Stomata of Pine (*Pinus sylvestris*), in addition to various herbs and ferns. Irish Elk and Reindeer have been found in deposits of Zone II, and the discovery of the beetle (*Calathus cisteloides*), a southern form known from Allerød layers in Northern Europe, proves that the climate was comparatively mild.

(3) *Zone III.*—This zone marks the return of arctic conditions, and the deposits formed at this time show the effect of solifluction. Pollen of *Oxyria digyna*, *Salix herbacea* and other herbaceous plants is common. As in the Baltic, Post-Glacial forest development begins with the cessation of the solifluction responsible for the formation of this layer.

The succession summarized above has been recognized at four bogs in Ireland —Ballybetagh, Co. Wicklow; Ralaghan, Col Cavan; Frenchpark, Co. Roscommon; and Roundstone, Co. Galway (Jessen and Farrington, 1938). Frenchpark and Roundstone are situated north of the Central Plains Moraines, a region which was not ice-free until during the 2nd Retreat Period (Fig. 1), therefore the development could not have begun earlier than this stage in the recession. Following Professor Jessen (1938), Zones II and III at all four localities are of the same age, and Ballybetagh Zone III is contemporary with the last advance of the Wicklow Ice. On this basis Zone III at the Central and Western Irish bogs must have been formed at the time of the Valley Glaciation, supporting the view that the last glacial maximum in the mountains of the southern section of Ireland should be referred to the Valley Glaciation Period (see p. 6). Thus palaeobotany substantiates the conclusions regarding correlations with Northern Europe, arrived at on the basis of a determination of the glacial stages in Britain and Ireland, as follows:

(*a*) the 2nd Retreat Period corresponds to the Gotiglacial, and Zone II (Allerød) was formed at this time;

(*b*) the Valley Glaciation Stage corresponds to the Fennoscandian End-Moraines—both were induced by an oscillation that in turn caused the formation of the solifluction layer (Zone III); and

(*c*) the beginning of Post-Glacial time (Zone IV) may be equated with the 3rd Retreat Period, which is the counterpart of the Finiglacial of Scandinavia.

B. Early Post-Glacial.—Thus far the final results of Professor Jessen's examination of Post-Glacial Irish peats have not been published. The following summary is based on the analyses of polleniferous deposits at Cushendun, Co. Antrim (Jessen, 1940), and the upper part of the Ballybetagh section in Co. Wicklow (Jessen, 1938). The development may be outlined as follows:

(1) *Zone IV.*—Post-Glacial Birch Period. Birch is dominant and attains a maximum in the upper portion of the zone. The greatest frequencies of Pine and Willow are in the lower part. The top of IV is marked by the point at which

the Hazel curve swings away from the vertical border in the diagrams. This zone corresponds closely with the Pre-Boreal Period (Zone IV) in the Baltic.

(2) *Zone V.*—The so-called Boreal Hazel maximum falls in this zone which witnessed the establishment of the first Post-Glacial high forests in Ireland. Ash was introduced at this time, but it is rare. The zone boundary V/VI is marked by the point in the diagrams where the Alder curve swings away from the vertical border. Zone V may be divided into two sub-zones (*a*) and (*b*):

(*a*) *Zone Va.*—In this horizon the Pine curve begins to rise; Birch and Willow tend to fall; and Hazel is coming in.

(*b*) *Zone Vb.*—The Hazel maximum occurs here; it attains a frequency of over 800 per cent in some cases. The Pine curve continues to rise and shows two maxima in upper Vb. Willow is rare; Birch is decreasing; there is a high frequency of Elm in the lower part of this zone; Oak is increasing, and in upper Vb it is dominant over Elm. Only traces of Alder are found. In the upper part of Vb the Hazel curve swings in.

Although it is not yet absolutely clear how Zone V in Ireland fits into the Danish sequence, it seems probable that Va is the equivalent of V in Denmark. Professor Jessen (1940, p. 46) suggests that the Boreal–Atlantic transition occurs at the point in Vb where the Hazel curve swings from the maximum, but the delayed appearance of Alder in Ireland makes this period more difficult to determine than elsewhere. Thus lower Vb is Late Boreal (Zone VI in Denmark), and upper Vb is Early Atlantic (approximating Danish Zone VII); however, further work is necessary before a more precise synchronization of the two systems is possible. Polleniferous deposits in North-East Ireland, which can be geologically dated in terms of the Litorina submergence, have been investigated and on this basis it seems reasonably certain that the Post-Glacial marine transgressions in Ireland and the Baltic are contemporary.

(3) *Zone VI.*—Alder now becomes dominant for the first time. Hazel is comparatively rare and reaches a minimum in the lower part of this zone. Elm and Oak decrease; Birch is present; and at the top of VI the Pine curve stops. The Post-Glacial climatic optimum occurs in the lower portion of this zone. Since the boundary between Zones VI and VII is fixed by an important "recurrence surface" (*Grenzhorizont*), also present in Denmark according to Jessen (see Mahr, 1937, pp. 276–278), it is very probable that Zone VI in Ireland may be equated with Zone VII in the Baltic. Thus in terms of the Blytt-Sernander system it is Late Atlantic–Sub-Boreal.

In spite of the fact that palaeobotany in Ireland is still in its infancy, as compared to the wealth of material in Northern Europe, the results to date are significant. Not only does the interpretation of the Late-Glacial diagrams strengthen the basis for correlating the sequence of the glacial stages, outlined on pp. 10–11, in terms of

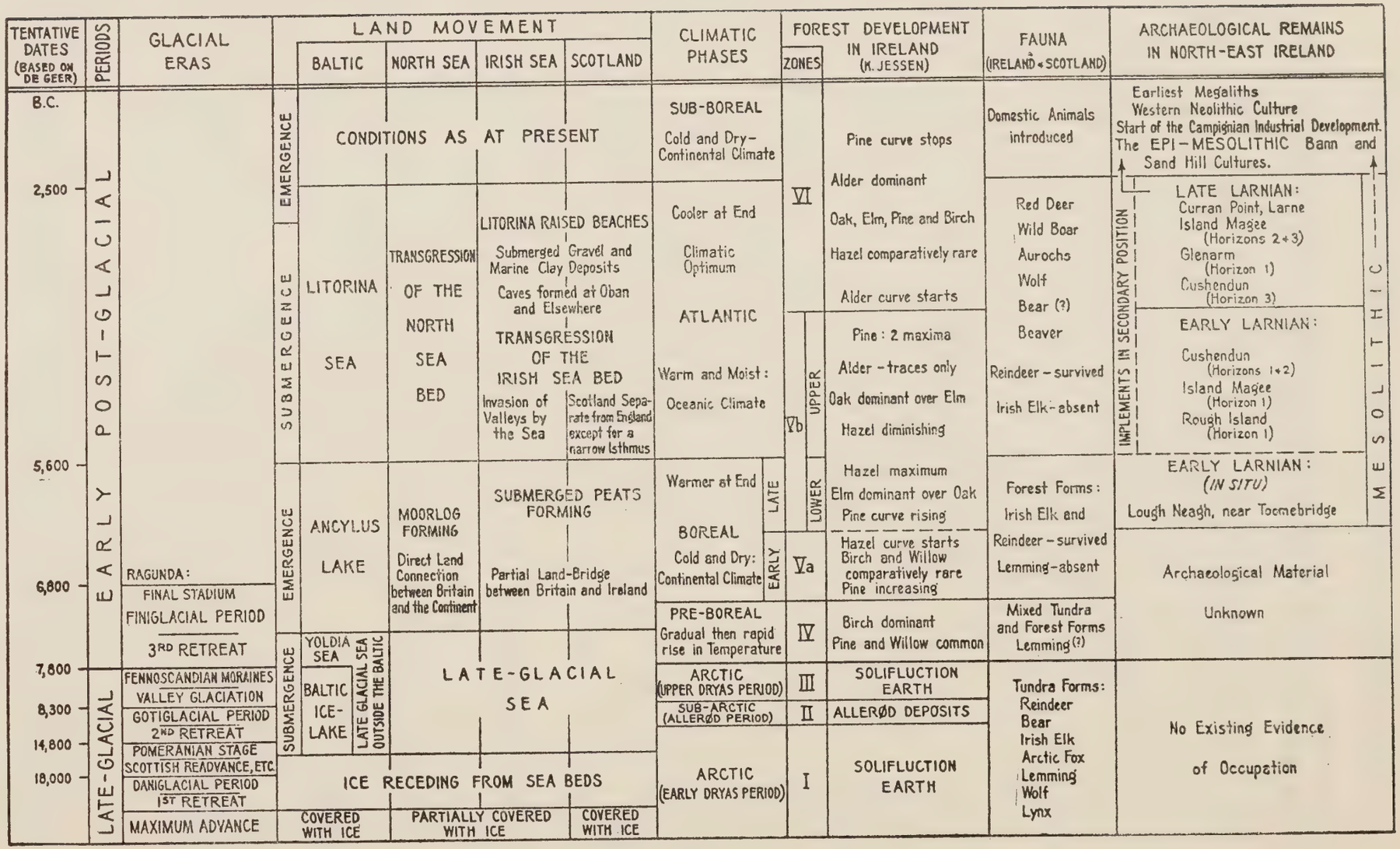
TENTATIVE DATES (BASED ON DE GEER)
PERIODS
GLACIAL ERAS
LAND MOVEMENT
BALTIC
NORTH SEA
IRISH SEA
SCOTLAND
CLIMATIC PHASES
FOREST DEVELOPMENT IN IRELAND (K. JESSEN)
ZONES
FAUNA (IRELAND & SCOTLAND)
ARCHAEOLOGICAL REMAINS IN NORTH-EAST IRELAND
B.C.
2,500
5,600
6,800
7,800
8,300
14,800
18,000
EARLY POST-GLACIAL
LATE-GLACIAL
EMERGENCE
SUBMERGENCE
CONDITIONS AS AT PRESENT
SUB-BOREAL
Cold and Dry-Continental Climate
Pine curve stops
Alder dominant
Oak, Elm, Pine and Birch
Hazel comparatively rare
Alder curve starts
VI
Domestic Animals introduced
Earliest Megaliths
Western Neolithic Culture
Start of the Campignian Industrial Development.
The EPI-MESOLITHIC Bann and Sand Hill Cultures.
LITORINA SEA
TRANSGRESSION OF THE NORTH SEA BED
LITORINA RAISED BEACHES
Submerged Gravel and Marine Clay Deposits
Caves formed at Oban and Elsewhere
TRANSGRESSION OF THE IRISH SEA BED
Invasion of Valleys by the Sea
Scotland Separate from England except for a narrow Isthmus
Cooler at End
Climatic Optimum
ATLANTIC
Warm and Moist: Oceanic Climate
Pine : 2 maxima
Alder - traces only
Oak dominant over Elm
Hazel diminishing
Hazel maximum
Elm dominant over Oak
Pine curve rising
Vb
UPPER
LOWER
Red Deer
Wild Boar
Aurochs
Wolf
Bear (?)
Beaver
Reindeer - survived
Irish Elk - absent
IMPLEMENTS IN SECONDARY POSITION
LATE LARNIAN:
Curran Point, Larne
Island Magee (Horizons 2+3)
Glenarm (Horizon 1)
Cushendun (Horizon 3)
EARLY LARNIAN:
Cushendun (Horizons 1+2)
Island Magee (Horizon 1)
Rough Island (Horizon 1)
MESOLITHIC
ANCYLUS LAKE
MOORLOG FORMING
Direct Land Connection between Britain and the Continent
SUBMERGED PEATS FORMING
Partial Land-Bridge between Britain and Ireland
Warmer at End
BOREAL
Cold and Dry: Continental Climate
LATE
EARLY
Va
Forest Forms: Irish Elk and Reindeer - survived
Lemming - absent
EARLY LARNIAN: (IN SITU)
Lough Neagh, near Toomebridge
Hazel curve starts
Birch and Willow comparatively rare
Pine increasing
RAGUNDA:
FINAL STADIUM
FINIGLACIAL PERIOD
3RD RETREAT
YOLDIA SEA
BALTIC ICE-LAKE
LATE GLACIAL SEA OUTSIDE THE BALTIC
LATE-GLACIAL SEA
PRE-BOREAL
Gradual then rapid rise in Temperature
IV
Birch dominant
Pine and Willow common
Mixed Tundra and Forest Forms
Lemming (?)
Archaeological Material
Unknown
FENNOSCANDIAN MORAINES
VALLEY GLACIATION
GOTIGLACIAL PERIOD
2ND RETREAT
POMERANIAN STAGE
SCOTTISH READVANCE, ETC.
DANIGLACIAL PERIOD
1ST RETREAT
MAXIMUM ADVANCE
ARCTIC (UPPER DRYAS PERIOD)
III
SOLIFLUCTION EARTH
SUB-ARCTIC (ALLERØD PERIOD)
II
ALLERØD DEPOSITS
ARCTIC (EARLY DRYAS PERIOD)
I
SOLIFLUCTION EARTH
Tundra Forms: Reindeer, Bear, Irish Elk, Arctic Fox, Lemming, Wolf, Lynx
No Existing Evidence of Occupation
ICE RECEDING FROM SEA BEDS
COVERED WITH ICE
PARTIALLY COVERED WITH ICE
COVERED WITH ICE

Fig. 2

the Scandinavian chronology, but it may be further demonstrated that changes of level common to both regions occurred at the same time. The obvious importance of this for dating archaeological material found in Early Post-Glacial deposits need not be emphasized.

7. Fauna in Ireland and Scotland

The Late-Glacial fauna of Ireland is well documented by cave excavations at numerous localities in Counties Waterford, Cork, Clare, and Sligo, which have been summarized by Forrest (1925–1927), but the only sites of this period thus far dug in Scotland are the caves at Inchnadamff, near Assynt, Sutherland (Peach and Horne, 1917; Callander, Cree and Ritchie, 1927; Cree, 1927; Ritchie, 1929). In both cases cold forms prevail. With regard to the land fauna of the Early Post-Glacial Period very little is known as yet, and it is extremely difficult to date the earliest appearance of new types. Ireland and Scotland are considered together, because, although the data are very meagre, the development in these two regions during the early periods appears to have been similar in every respect.

As in the case of the forest succession the advent of the climatic optimum is heralded by the arrival of new types. This led to a change, but the transition was not abrupt; the Late-Glacial animals were gradually replaced by temperate, forest-loving species. Many typical Late-Glacial forms survived well into Post-Glacial times, but certain species such as the Arctic Lemming, apparently became extinct with the final disappearance of the ice. Remains of Irish Elk (*Megaceros giganteus*), characteristic of the Late-Glacial Period, have been reported from the Late Boreal submerged peats of Belfast Lough by Dr. Praeger (1888 and 1892) and Robert Young (1894), but there is at present no evidence that this animal survived as late as Atlantic times. The Reindeer, however, lingered in Caithness until the 12th century (Hinton, 1926); in Ireland the date of its extinction is unknown. Similarly the Wild Ox—the Aurochs —seems to have been present (Jones, C. B., 1932), and it has been found at several Post-Glacial localities in Scotland (Gregory and Currie, 1928), although it disappeared before the Roman Period (Gregory, 1927, p. 372). The most common forms which have been discovered in Early Post-Glacial deposits in Scotland and Ireland include Red Deer and Wild Boar. The earliest appearance of Horse and Elk (*Alces alces*) in Scotland occurs here (Gregory and Currie, 1928); other typical forms are Wolf, Bear and Beaver. In Ireland the Wolf survived from Late-Glacial times, and its remains are found in Iron Age sites. With the exception of a few birds, known from the upper levels at Inchnadamff (Peach and Horne, 1917), this exhausts the list. The limited number of genera represented is a direct reflection of the very few primary occupation sites of the Early Post-Glacial Period thus far excavated in Northern Britain and Ireland. Nevertheless, it is clear that as the climate ameliorated new types gradually replaced the old which survived on the periphery and in refuge areas into a comparatively recent period.

8. Archaeological Remains in North-East Ireland

The evidence from Victoria Cave in Northern England (Boyd Dawkins, 1874; Breuil, 1922; Clark, 1932, p. 14; Garrod, 1926, p. 120) and Scotland (Breuil, 1937; Callander, Cree and Ritchie, 1927) demonstrates that Stone Age hunters moved northward, as the ice withdrew during the Late-Glacial period and more land became available for occupation. In Ireland, however, there is as yet no evidence to prove that settlement was effected until Boreal times. The oldest archaeological deposit discovered to date is on the northern shore of Lough Neagh not far from Toomebridge (Whelan, 1933, p. 1213; 1933(a) and 1938, p. 128), and it is sealed below Late Boreal peat (Erdtman, 1932) which seems to belong to Zone Vb in Ireland (Jessen, 1940, p. 51). The industry from this site may therefore be assigned to the Mesolithic Period; it is Early Larnian in type (Movius, 1940, p. 67). By far the richest stations, however, are those on the north-east coast where there is an almost inexhaustible supply of flint. This fact was first mentioned by Du Noyer (1869), and subsequent work by Bremer (1928), Burchell (1931), Coffey and Praeger (1904), William Gray (1880 and 1890), Knowles (1914), Layard (1909), Patterson (1896), Praeger (1890), W. J. Simpson (1889), Whelan (1928, 1930, 1933, 1934, and 1938) and others, has brought to light an enormous amount of valuable information. Recent excavations by the Harvard Archaeological Expedition to Ireland at Cushendun (Movius, 1940), Glenarm (Movius, 1937) and Larne,[1] all in County Antrim, and Rough Island, County Down (Movius, 1940a), as well as Mr. J. P. T. Burchell's investigations at Island Magee near Larne, County Antrim (1932, 1933 and 1934; Baden-Powell, 1937), have provided a stratigraphical basis for subdividing the Irish Mesolithic into two phases, which is substantiated by typology. Furthermore, it is now possible to date this material not only in terms of changes of level, but also in terms of climatic phases and forest development (see Fig. 2). Thus the Early Larnian is found in secondary position in deposits of Upper Zone Vb (Early Atlantic), whereas the Late Larnian, also derived, always occurs in levels laid down during the early and middle portions of Zone VI (Late Atlantic). In other words, the Early Larnian comes from sediments formed during the first half of the sinking; the Late Larnian, on the other hand, is known only from levels dating from the maximum of the transgression and the storm-beaches thrown up by wave-action during the time of emergence. Since in both phases—early and late—the material is in secondary position, it is probable that it was derived by the sea during the sinking and that it comes from sites along the foreshore of an older period. On this basis it seems very probable that the Early Larnian should be referred to the Late Boreal and the Late Larnian to the Early Atlantic. Strictly speaking therefore, the Late Atlantic Period is a lacuna in Irish archaeology.[2]

With the change of climate during the second half of the third millennium B.C. at the end of Atlantic times, important new influences penetrated Ireland. These came from two main sources: (*a*) directly from the south and west via the Iberian

[1] Publication forthcoming in *Proc. Royal Irish Academy*.

[2] A shell midden of this period was found on Rough Island, but it was archaeologically sterile.

Peninsula and the Atlantic (Early Megalithic Culture), and (*b*) from the Continent via Britain (Western Neolithic Culture). Western Europe is likewise the region which apparently gave rise to an industrial development known as the Campignian. But as far as can be determined the Campignian is *not* a culture; rather it is a technique for manufacturing flint and stone implements. This technique was introduced into North-East Ireland, along with Western Neolithic Culture, at this time (compare: Knowles, 1903 and 1906; Movius, 1937; Whelan, 1934 and 1938), and it persisted as long as flint and stone implements remained in common use. In addition to the introductions mentioned above, which brought in their wake the new art of food-production, the indigenous food-gatherers survived in the interior and in the sand dune regions of the coast. Certain forms typical of the Bann Culture are clearly derived from Larnian prototypes (Movius, 1936 and 1940), whereas in the Sand Hills, as indicated by Mahr (1937, p. 336), the Mesolithic tradition persisted as late as the Early Christian Period (Buick, 1891; Coffey and Praeger, 1904, p. 191; Hassé, 1894). For this reason the Bann and the Sand Hill developments are regarded as Epi-Mesolithic, although they were strongly influenced by whatever culture was dominant in the region at a given time.

9. Conclusions

From the foregoing remarks it is clear that archaeology is of little help for purposes of dating the Early Post-Glacial deposits of North-East Ireland. It is only when the sum total of the evidence is considered and synthesized that the horizons in question may be interpreted. Since each individual line of approach leads to the conclusion that in Britain and Ireland the sequence repeats the established North European pattern, there seems to be no valid objection to extending the chronology of the latter region into these islands. Many events common to all three areas are of the first magnitude of importance, and it is improbable that they did not happen simultaneously. In other cases the peaks may not be absolutely uniform, but future research will establish more precisely where these occur as well as how they may be synchronized. For our present purpose of fixing the chronology of the Irish Stone Age, however, the evidence summarized in this paper provides a fairly satisfactory background. This background can be further extended to reconstruct the environment which gave rise to the Larnian Culture in Ireland and, as described elsewhere (Movius, 1940), to the Obanian in Scotland.

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